REP 1997-093
071

REPELLENT COATINGS FOR IRRIGATION HOSE: EFFECTIVENESS AGAINST COYOTES

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Abstract: Coyotes (*Canis latrans*) sometimes chew drip irrigation hose, causing economic damage. We designed the present experiment to test whether repellent coatings might deter chewing. We randomly assigned 12 coyotes to three groups (n=4/gp). During pretreatment (days 1–4) and post-treatment (days 9–12), we presented animals with two 0.5-m pieces of untreated drip irrigation hose in 1-choice 5-h tests. During treatment (days 5–8), we presented different groups with an untreated piece of hose, and a hose coated with a candidate repellent [1.0% (volume/mass) capsaicin, pulegone, or lithium chloride]. All repellents reduced chewing in comparison with pretreatment by approximately 40%. During post-treatment, chewing returned to pretreatment levels. This suggests that animals were avoiding repellents, *per se*, and were not learning to avoid hose. We speculate that repellent coatings may protect irrigation hose in the field; both sensory (capsaicin, pulegone) and post-ingestive (lithium chloride) agents warrant further consideration.

Key words: *Canis latrans*, capsaicin, coyote, lithium chloride, pulegone, repellent

J. Wildl. Res. 2(2): 146–148, 1997

INTRODUCTION

Drip irrigation systems are widely used in the southwestern U.S. for crop irrigation (Callan and Westcott 1996). For reasons that remain obscure, coyotes (*Canis latrans*) are attracted to these systems. Hoses are punctured by biting, and this damage causes substantial economic loss. Because sections of damaged hose are difficult to identify, entire sections must be replaced. In Fresno County, California, coyote damage to irrigation hose in 1995 exceeded $200,000 (J. Rinder, Calif. Dept. Agric., pers. comm.).

Repellents may be useful to prevent coyote damage to irrigation hose. While no repellent is specifically available to deter biting by coyotes, a number of possibilities exist. For example, a variety of patents describe commercially available substances that repel dogs. These substances include cinnamaldehyde and beta-phenylacrolein (Haase, U.S. Patent No. 4,169,898), methyl nonyl ketone (Haase, U.S. Patent No. 4,555,015), allyl isothiocyanate (Downing, U.S. Patent No. 4,440,783), limonene and alpha-terpinyl methyl ether (Katz and Withycombe, U.S. Patent No. 4,735,803), various carboxylated hydrophilic acrylic copolmers (DeLong, U.S. Patent No. 4,169,902), gamma-n-alkyl-gamma-butyrolactone and gamma-n-alkyl-gamma-valerolactone (Meuly, U.S. Patent No. 3,923,997), various steroids (Hansen et al., U.S, Patent Nos 4,534,976; 4,657,759; 4,668,455), red pepper (Loucas, U.S. Patent No. 5,368,866), quinine (Loucas, U.S. Patent No. 5,368,866), and pulegone (Mason, U.S. Patent Application No. 351,841).

In the present experiment, we investigated three candidate repellents for the prevention of coyote damage to irrigation hose. Capsaicin was selected because it is a dog repellent (Loucas, U.S. Patent No. 5,368866) and is generally aversive to mammals (Rozin et al., 1979). Capsaicinoids (Hoffman et al. 1983) are the active integredients in Capsicum or red peppers. Aversiveness is exclusively a consequence of chemosensory irritation (Szolzsanyi 1990).

Pulegone was selected because it is repellent to dogs (Mason, U.S. Patent Application No. 351,841), coyotes (Hoover 1996), and other vertebrates (Mason 1990, Avery et al., in press). Aversiveness is a consequence of both chemosensory irritation and gastrointestinal malaise (Mason and Primus 1996).

Lithium chloride was selected because it induces learned avoidance in all vertebrates tested to date including coyotes (Garcia and Riley in press, Gustavson et al. 1974). Avoidance of lithium chloride-treated materials is learned as a consequence of gastrointestinal malaise. Lithium chloride does not have inherently aversive sensory characteristics, and to humans, it tastes like sodium chloride (Beauchamp and Mason 1991).

Drs. L. Clark, A.L. Riley and W.M. Tzilkowski provided useful comments on earlier manuscript drafts.

MATERIALS AND METHODS

Subject. Twenty-three adult (14 males and 9 females; ≥1 year old) coyotes served as experimental subjects. Animals were randomly selected from the colony maintained at the Millville Predator Research Facility of the National Wildlife

Table 1. Mean punctures (± standard errors of means) of irrigation hose by coyotes during pretreatment, treatment, and post-treatment.

Capsaicin		Pulegone		Lithium chloride	
Pretreatment (left *vs.* right hose)					
3.0±0.41	3.5±0.29	3.75±0.25	2.75±0.63	2.5±0.87	3.25±0.48
Treatment (repellent-treated *vs.* untreated)					
0.25±0.25	2.5±0.50	1.5±0.65	2.5±0.87	1.0±0.58	2.25±0.63
Post-treatment (left *vs.* right hose)					
2.75±0.63	3.0±0.41	2.25±0.85	2.25±0.85	2.5±0.87	2.75±0.75

Chemical (regardless of treatment period)		
Capsaicin	Pulegone	Lithium chloride
2.5±0.27	2.5±0.29	2.37±0.29
Period (regardless of chemical)		
Pretreatment	Treatment	Post-treatment
3.12±0.25	1.70±0.28	2.58±0.31

Research Center. Throughout the experiment, animals were fed 600-g of ground meat daily. Water was available *ad libitum* throughout the experiment.

Stimuli. Capsaicin (CAS#404–86–4), d–pulegone (CAS #89–82–7), and lithium chloride (CAS#7447-41-8) were purchased from Aldrich Chemical Company, Milwaukee, WI. Corn oil (Mazola) was obtained from a grocery store. Stimulus solutions were prepared by dissolving 10.0-g of capsaicin, pulegone, or lithium chloride in 1–l of corn oil.

Procedure. On each of four consecutive pretreatment days, 23 coyotes were presented with two 0.5-m pieces of polymer drip irrigation hose (2.5 cm diam., Tenkor Apex Manufacturing, City of Industry, CA). Baling wire was used to attach hose sections to the front panel of each kennel. Sections were positioned approximately 0.25 m apart and 0.5 m above the floor. Presentations occurred over 5 h between 10:00–15:00 h MST. At the end of each trial, hoses were removed and examined for bite punctures by two observers.

Twelve animals consistently bit and punctured untreated hose during pretreatment. These animals were randomlyassigned to three treatment groups (n=4/grp). During a 4-day treatment period, each group was presented with two 0.5-m pieces of hose between 10:00–15:00 h daily. One hose was untreated, while the other was coated with a candidate repellent. Corn oil and repellent coatings (approximately 25 ml) were applied with a paint brush, and occurred just prior to testing. Excess coating was allowed to drip away, so that only a thin film remained. Group 1 was exposed to capsaicin, Group 2, to pulegone, and Group 3, to lithium chloride.

During a 4-day post-treatment period, animals were again presented with two pieces of untreated hose between 10:00–15:00 h. Procedures were identical to those described for pretreatment.

Analysis. Punctures by each animal were averaged between observers and across days within each period, and a 3-factor analysis of variance (ANOVA) was used to assess these scores. The independent factor in this ANOVA was groups (3 levels), while the repeated factors were period (3 levels) and hose (2 levels). Subsequent to the omnibus procedure, Tukey tests (Winer 1971) were used to isolate significant differences among means. (p<0.01).

RESULTS

There was a significant difference in overall puncture scores among periods (F=15.4; 2,18 df, p=0.0003). Post-hoc tests showed that scores were less during the treatment period than during pretreatment or post-treatment (Table 1). Otherwise, there were no significant differences (ps>0.10).

MANAGEMENT IMPLICATIONS

All candidate repellents reduced biting during the treatment period. The finding that this reduction was non-selective (i.e., not just for treated hose, *per se*) suggests that at least some of the animals may have been unable to discriminate between treated and untreated hoses. This lack of discrimination might reflect the proximity of hoses during test sessions, and/or the small number of animals tested. That a few animals were able to discriminate treated from untreated hose is suggested by (not significant) trends between means within groups (i.e., biting and chewing of treated hose appeared less than biting and chewing of untreated hose).

Drip irrigation hose is damaged by coyotes, resulting in substantial economic loss. The present results suggest that sensory (capsaicin, pulegone) or post-ingestive (lithium chloride) repellents might be used to manage this damage. Because the simplicity of kennel tests does not reflect the complexity of the field, more extensive investigations are warranted. Nevertheless, we feel that the present experiment is a strong test of repellency, since animals were presented with hose for 5-h daily in a relatively impoverished environment (i.e., in the absence of diversions).

While any of the three repellents tested hold promise for use as a topically applied repellent, both capsaicin and pulegone are relatively difficult to solubize, and lithium chloride has some phytotoxic properties. These obstacles might be overcome via microencapsulation. Also, other repellents may exist. We recently evaluated the responsiveness of coyotes to a variety of tastes, including several bitter substances (i.e., denatonium benzoate, sucrose octaacetate, quinine hydrochloride; Mason and McConnell 1997). Neither denatonium benzoate nor sucrose octaacetate reduced consumption, but quinine hydrochloride produced substantial reductions in consumption. This finding is consistent with the observation that quinine effectively repels dogs (Loucas, U.S. Patent No. 5,368,866). Because quinine hydrochloride is water-soluble, it could be applied to hose topically, or added to irrigation water. A caveat to this approach is that translocation of quinine by plants needs to be evaluated to determine whether it might negatively affect the marketability of a crop. Because quinine is much easier to handle than capsaicin or pulegone, and because it is substantially less expensive, tests of this tastant are being planned.

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